

Geologists assist in TMI-2 core assessment

When geologist Dick Smith began working for EG&G a year ago, he didn't anticipate that he would be involved with Three Mile Island. It just didn't seem like a likely project for a geologist. However, after 10 holes had been bored through the TMI core and the interiors of the holes videotaped, the tapes were made available to Bill Downs, manager of EG&G's Geology unit. "Our task was to map the different zones in the TMI core and estimate the amount of material in each zone," says Downs. Downs and Smith, working with Bert Tolman, Bud Russell and Jim Broughton of the TMI-2 Accident Evaluation Program who identified the probable types of materials in the various zones, estimated the axial and radial boundaries of each zone.

Prior to the core boring, it was known that the upper core consisted of an upper void region almost entirely surrounded by standing peripheral assemblies and a region of loose debris resting on a hard crust. Conditions within the confines of the core boundary beneath the hard crust were unknown.

To investigate the lower region, a core bore system was developed from a commercially available unit built for the mining/geology industry which is installed on the defueling platform erected above the TMI-2 reactor vessel. The system was designed to extract 2.5-inch diameter corings from the center of each drilled hole. A total of 10 holes were drilled in the TMI-2 core in July of 1986. Immediately following the drilling of each hole, the hole was "cased" with steel pipe by drilling with a slightly larger (4.5 inch) bit. A small diameter video camera was inserted down the casing, and the entire depth of the hole was then examined by slowly withdrawing the casing while raising and rotating the video camera.



A TRANSPARENT PLASTIC model of the core as mapped by geologist Dick Smith was built by David Sharp and Craig Walker of EG&G Graphics. On the lower left of the mass, shown by a small dark area, is the location of the "breakout."

From videotapes of the drilled holes, Smith was able to put together vertical cross-sections showing the different types of material. Two major zones were identified in the lower portion of the damaged core: an outer agglomerate of previously molten fuel material surrounding unmelted fragments of partially intact fuel pellets and an inner zone of previously molten homogeneous ceramic interlaced with metallic stringers. Melting of this ceramic material requires a minimum temperature of 4580 degrees Fahrenheit and in some cases as high as 5120 degrees Fahrenheit.

Initially, it was expected that "breakout" would occur at the core center since heat was symmetrically distributed in the core and, should a significant fraction of the core become molten, material would flow out of the bottom in the center to the lower plenum of the reactor vessel. The big surprise was discovering that it did not follow this expected path but instead penetrated the top or side of the crust of agglomerate and flowed down near the southeast periphery of the reactor.

Downs says, "We believe that when it went, it was truly spectacular—23 tons of material was released in seconds to a few minutes, flowing down the side and coming to rest on the bottom of the reactor vessel." The videotape evidence of the probable course of this major relocation of the core is supported by the behavior of the external neutron detectors which showed big spikes in neutron flux indicating that fuel material went from a shielded portion of the reactor vessel to an unshielded location very quickly.

A transparent plastic model of the end state reactor core was built by David Sharp and Craig Walker of EG&G Graphic Arts using colored plastic panels. Smith delineated the shapes and locations of the various core regions inside the model which represented the cross-sections constructed from the video data. By putting

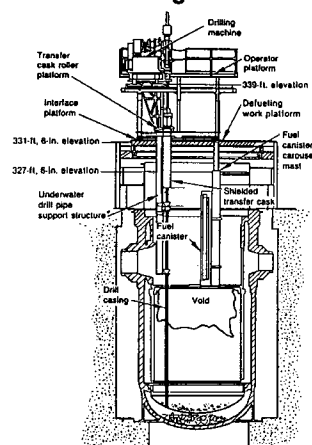
together the cross-sections and interpolating between them, the geologists could verify the earlier estimate that approximately 23 tons of material was relocated to the lower plenum. "We now know basically what the core looks like, and this visual evidence gives us a much better idea of what occurred and when it occurred during the accident," says Smith.

"Something we weren't sure of when we started," says Downs, "was what the top of the melted core looks like. The surface of the previously molten layer was quite irregular." It is possible to speculate on several ways that the irregular surface could have been formed. One such speculation might be that as material in the center melted, the pressure of the overlying material would squeeze some of the molten core up into the areas that were slightly more permeable, making cones in the overlying material; channels were also created when the material was squirted out the side. The molten substance carried some of the overlying materials with it similar to the way a river carries an ice flow with it.

One of the other discoveries was that some metal in the core was melted but not oxidized. When cooling occurred, the previously molten metal solidified, cementing core fragments together like reinforcing rods. This has caused complications in removing the core.

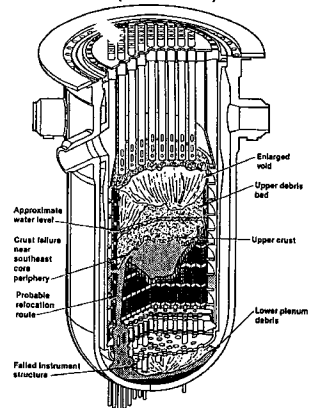
Downs and Smith agree that it was a challenging and very interesting project. Downs notes that although the Geology Unit is an integral part of the INEL Research Center, they rarely have the opportunity to become involved in ongoing nuclear engineering projects. This was one project where Geology proved useful in providing answers for the nuclear field.

Core Boring Machine



THE CORE BORE system was developed from a commercially available unit built for the mining/geology industry and is installed on the defueling platform erected above the TMI-2 reactor vessel as shown above.

Hypothesized Core Damage Configuration (226 Minutes)



THE ABOVE DRAWING shows the hypothesized core damage configuration determined from the videotapes and the geologists' work.